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The green paradox and learning-by-doing in the renewable energy sector☆

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ABSTRACT

The green paradox conveys the idea that climate policies may have unintended side effects when taking into account the reaction of fossil fuel suppliers. The prospect of carbon taxes being implemented in the future induces resource owners to extract more rapidly which increases present carbon dioxide emissions and accelerates global warming. However, our results suggest that future carbon taxes may decrease present emissions if resource owners face increasing marginal extraction costs and if there is a clean energy source that is a perfect substitute and exhibits learning-by-doing (LBD).

If the marginal extraction cost curve is sufficiently flat, resource owners respond to a future carbon tax by lowering total extraction and only slightly increasing present extraction. Moreover, taxation leads to higher energy prices which induces renewable energy firms to increase output not only in the future, but also in the present because of the anticipated benefits from LBD. This crowds

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out energy from the combustion of fossil fuels and may outweigh the initial increase in present extraction, leading to less emissions in the present.

1. Introduction

Carbon taxes that effectively combat global warming do not seem to be politically feasible in the short run as the climate conferences in Copenhagen, Doha and Lima have demonstrated. Therefore, policy makers are restricted to the taxation of carbon dioxide (CO_2) emissions in the future. However, the implementation of delayed carbon taxes threatens resource owners, inducing them to extract their stocks more rapidly. This reaction is referred to as green paradox because it causes higher CO_2 emissions in the present and accelerates global warming. With the acceleration of global warming, both climate change damage and adaptation costs are expected to increase making it crucial for policy makers to take the green paradox into account when designing climate policies.

This paper challenges the green paradox, demonstrating that delayed carbon taxes may even decrease current emissions if the two following conditions are met: first, resource owners face increasing marginal extraction costs and second there is a clean energy source that is a perfect substitute and exhibits learning-by-doing (LBD). LBD originates from the routinization of the production process or from minor technological improvements. It can be thought of as endogenous technological change which essentially lowers the costs of future production depending on accumulated production or experience of the past.[2] If the marginal extraction cost curve is sufficiently flat, a delayed carbon tax induces resource owners to reduce the fossil fuel supply substantially and to shift only a very small amount of extraction into the present. Additionally, taxation yields higher future energy prices which induces the clean energy sector to expand production not only in the future, but also in the present due to the anticipated benefits from LBD. Expanded production in the present reduces the current energy price and induces resource owners to postpone extraction. If this effect is sufficiently large, it will outweigh the initial increase in present extraction, leading to less emissions in the present.

Eichner and Pethig (2011) also found that delayed taxation of fossil fuels (in the form of a tighter emissions cap in the future) may even reduce current emissions. However, in their model, the reason for this is the existence of a second country which does not implement any climate policy. Tightening the emissions cap in the future by the abating country has essentially two effects: first, in the abating country the consumer price for fossil fuels in the future increases, causing households to consume more fossil fuels in the present so that present emissions increase. Second, the world price for fossil fuels in the future decreases which is why households in the non-abating country have an incentive to substitute present consumption of fossil fuels by future consumption, leading to fewer emissions in the present. Under certain conditions concerning the elasticities of fossil fuel demand and intertemporal substitution, the second effect will outweigh the first and current emissions will decrease, meaning that there is a reversal of the green paradox.[3] Our paper also shows a reversal of the green paradox, though not because of the presence of a second country, but rather due to the effect of LBD. Since our focus is on LBD, we use a one-country setting which is in line with the bulk of the green paradox literature.

The term green paradox was first coined by Sinn, 2008a and relates the theory of exhaustible resources (Hotelling, 1931; Dasgupta and Heal, 1979; Long and Sinn, 1985) to environmental policies. Starting with Sinclair (1992), the vast majority of this literature assumes constant or zero extraction costs for exhaustible resources (Ulph and Ulph, 1994; Withagen, 1994; Sinn, 2008b) and the existence of a clean backstop technology that supplies an unlimited amount of energy, but at a higher

[2] The static correspondent to LBD would be economies of scale. However, under economies of scale, the cost reduction in unit costs originates from the distribution of fixed costs on all units produced and not (as it is the case under LBD) from a more efficient way of production as the output increases.

[3] A similar result is found by Ritter and Schopf (2014) and van der Meijden et al. (2015) in a general equilibrium model.